Knowledge Management for Public Administrations: Technical Realizations of an Enterprise Attention Management System

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Abstract: The improvement of governments' efficiency has gained great importance and validity especially in the current times of economic downturn. E-Government constitutes the most contemporary techno-managerial proposition in the track of possible interventions. The paper addresses, more specifically, empowerments necessitated by Public Administration (PA) organizations. Anchored on the needs of three real-life cases, the paper describes the conception and the realization of an IT artefact together with its methodological appeals aiming at improving information access and delivery and thus PAs' decision making capacity. Our proposition constitutes a novel approach for managing users' attention in knowledge intensive organizations which goes beyond informing a user about changes in relevant information towards proactively supporting the user to react on changes. The approach is based on an expressive attention model, which is realized by combining ECA (Event-Condition-Action) rules with ontologies. The technical realizations described in the paper constitute the underlying infrastructure of an Enterprise Attention Management System.

Keywords: Attention management, proactive information delivery, public administrations, semantic infrastructures, intervention methodology

1. Introduction

The advent of the e-governance era inevitably poses new challenges for public administrations effectuating continuous monitoring and adaptation to changing legislative and political environment, predicting citizens' and business needs accurately, and making right decisions. The public sector is therefore by far one of the most knowledge-based and intensive organizations, thus making it ideal for KM interventions.

KM has a clear mandate for e-government to enable and promote the requisite information and human mechanisms for the advancement and sustainability of competence-driven service delivery (Ping, 2008).Still any attempt to manage knowledge would suffer from two seemingly competing requirements: managing humans' cognitive capacity vs. organizational knowledge abudance. To avoid such deadlocks, we capitalize on a KM approach that is based on a model of information delivery, which utilizes human attention capacity as a means to tackle "proactively" any information requests of knowledge workers.

This knowledge perspective recognizes workers as a source of knowledge in their respective roles (Devadoss and Pan Shan , 2002). Any intervention in this respect should make allowances for the support of the human factor and in particular its on-the-job requirements and significations. Our claim goes beyond existing empowerments for the structuring, searching and discovery of knowledge, concentrating on the importance of making information more readily and meaningfully available to its seekers and therefore any reaction on it more (pro)active. The realization of this approach necessitates the understanding of the functioning of human attention in order to capture and model the requirements for proactive information delivery.

Our ideas for proactive information delivery were realized in the SAKE project and subsequently in the produced system and methodology. In this paper we demonstrate the origins but also the products of our KM approach, which is based on the idea of proactive information delivery by technically enabling attention management. Our paper is split in 3 main cores. The first core accounts for the knowledge environment of public administration organizations along with the specification of three real life (3) application scenarios. The second core is dedicated to the technical design and implementation of the proposed solution and last we present the basic conceptual strands of our methodological framework.

2. The knowledge landscape in Public Administrations

Public Administrations (PA) represent the backbone of any political system. Involved at all stages of the policy-making process, PAs also play the role of the interface between citizens and the political system, thus acting as an efficient catalyst for the process of transferring political measures towards society. Nowadays, contemporary societal developments impose the modernization of PAs in order to achieve higher levels of efficiency in the delivery of public

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service. In this realm, KM introduces new options, capabilities, and practices that can impact and assist public administration to great advantage (Wiig, 2000). For Public Administrations, the management of their knowledge landscape comprises a new responsibility and certainly leads to the heart of administrative work where decisions are taken.

The knowledge landscape in public administrations consists of knowledge relevant for problem solving and decision making. This knowledge is represented in explicit forms of content like documents and database records enabling its effective retrieval. However, knowledge is not static; it evolves as it is being used by its consumers. This perspective of knowledge differs significantly from the one ascribed by traditional and static information management views (Balatsoukas, 2005).

The "changeability" of knowledge is usually reflected on metadata, like creation date, last modification, how often a document has been changed, etc. However, metadata alone are not sufficient to capture the dynamic nature of knowledge and specifically any changes related to its purpose and scope of application. Factors that apparently influence knowledge changeability are the *form of representation* of knowledge, the *context* of application and individual *preferences*. Knowledge is no longer manifested by static and re-active information structures such as usage stamps (time, person, purpose, etc.) and cataloguing rules (clustering, etc.) but could be continuously redefined based on its role in the organizational landscape. In its new structure, knowledge codification is enhanced with information elements acquired during its lifespan rather than any human ex-post attributions. Failing to capture knowledge changeability might result in both knowledge stickiness and leakiness (Brown and Duguid, 2001).

In knowledge-based environments like PAs, where knowledge is endless and chaotic and human mediation is overwhelming, KM needs to facilitate efficient access to information and knowledge by enabling information seekers' attention with appropriate IT-based mechanisms. Managing people's attention will result in more relevant and important information and knowledge to reach its seekers. Our approach for KM is built on this premise.

3. Application Scenaria for KM: The case of 3 public administrations

Our proposition does not stem only from conceptual inquiries but is also grounded in the requirements of three actual PA organizations fromHungary, Poland, and Slovakia. Due to their recent endorsement by the European Union (EU), these countries are still struggling to meet the quality criteria of EU in several areas of public services. This task becomes harder considering the PAs' heterogeneity within the boundaries of a single country, let alone at the pan-European level. This heterogeneity is increased due to the complexity of activities of the PAs, the continuous political changes as well as their scope (regional, national, international). Amidst these conditions, these PAs participated in the formulation of a KM solution that could eventually support them in their knowledge-intensive tasks. Below are the areas of the envisaged support for each PA:

- LATA (Mestska cast Kosice – Sidlisko Tahanovce): involvement of the public into the process of making local legal regulations by annotation of the city ward general binding regulation.
- MEC (Ministry of Education and Culture): higher education portfolio alignment with world of labour needs.
- UMC (Urząd Miasta Czestochowy): management of education institutions' material resources.

All three cases concern processes in PA environments that target citizens, businesses, or PA-internal groups. Several aspects demonstrate the knowledge- and information- intensiveness oftheir environment:

- They depend on a number of applicable laws, regulations, court decisions, etc.
- They typically process a huge amount of information and documents from different sources
- They require continuous monitoring of the content of the employed knowledge resources as they frequently become subject of change
- The application and interpretation of law and regulation is often not trivial, ambiguous, such that it requires experience in the field but also constantly updated knowledge
- Content items logically belong together (e.g. a regulation interprets a law in a more or less binding manner, while example cases illustrate the borders of applicability) and are only valid in a certain, complex application context (which region, which timing of events, which kind of citizen or decision, …)

User requirements were collected through workshops between PA stakeholders and the project's intervention team(partners acting as consultants). Our on-site inquiry led to the inception of a technical and management intervention constituted by empowerments on the content and collaboration functions of the Pas i.e. monitoring changes in laws, capturing purpose-oriented interactions and communications, etc.

Our requirements analysis also included detailed mapping of the knowledge landscape of the three PAs as constituted by processes, knowledge assets and knowledge agents. Specifically our inquiry focused on eliciting detailed description of the targeted processes in terms of knowledge inputs/outputs, communication modes and knowledge agents, the detailed description of knowledge assets (as the main input for the ontology population), and the detailed description of knowledge agents.

Finding a purpose for KMOur analysis led to the identification of pertinent to the public administrators empowerments that are dominated by the need to control information in its context of usage. Consequently, we adopted the notion of changeability to address the breadth of possible situations that an information resource can be found in during its lifespan. Given information lives within a social context, it would be a mistake from our behalf to leave the human factor unaddressed (Brown and Duguid, 2000). People comprise the basic sense-giving instrument for information. We perceive sense as a blend of value and meaning that is enacted by humans during the utilization of information in work. The maximization of these two aspects will inevitably lead to better decision making and problem solving.

Apparently, access to information is not the problem. Accessing information that is relevant, meaningful and valuable for our work is. Given humans' bounded capacity to process information, proactive delivery of knowledge and information becomes an imminent priority. Our treatment for this matter comes through managing the attention of knowledge workers. In our approach, there are three main requirements for modeling attention (to be further discussed later):

- Modeling information sources that should be accessed, in order to enable focusing on relevant ones
- Modeling context in which information should be received, in order to define the business context in which information will be consumed
- Modeling preferences of users, in order to express individual "context" in which information will be used

Based on requirements from three public administration organizations and also our technical aspirations for a KM solution, we endeavored to implement a technical solution that provides:

- an integrated knowledge space (instead of a set of isolated and heterogeneous knowledge resources) that will unify different perspectives and interpretations of knowledge resources and will enable their treatment on a far more fine grained level: now any bit of information or any knowledge object could be given identity (so called virtual content) and assigned attributes (metadata) allowing for more sophisticated applications and services in e-government;
- a collaborative working environment (instead of a single person decision making process) that will bring every public servant to the same level of effectiveness and productivity and will ensure more efficient knowledge sharing by guaranteeing at the same the time the reliability and the consistency of the decision making process;
- a change management system (instead of ad-hoc management of changes) that will ensure harmonisation of requests for changes, resolution of changes in a systematic way and their consistent and unified propagation to the collaborative and knowledge space, in order to ensure the high quality of the decision-making process;
- a platform for proactive delivery of knowledge (instead of an one-way knowledge access) that enables creation of an adaptable knowledge sharing environment through learning from the collaboration between public servants and their interaction with the knowledge repository and supporting in that way full empowerment of public servants.

4. Underpinnings of Attention Management

4.1 Related Work

Our claims for proactive information delivery using the notion of attention management are not new. Next we present the most representative initiatives.

Researchers from IBM and MIT designed and developed the *Simple User Interest Tracker* or *SUITOR* (Maglio et al., 2001) which is a framework for developing attentive information systems that track computer users through multiple channels to determine interests and to try to satisfy information needs. SUITOR implements four main modules: a) watching user's actions to infer user's current mental state and needs, b) storing user's actions to create and maintain user's model, c) searching information from the digital world and scanning user's local hard disk and d) ranking and suggesting relevant information sources through peripheral display. Having enough input information from these modules, SUITOR can infer user's current interests and propose relevant information sources from local and remote databases that have previously gathered and stored.

The *Attentional User Interface project* (Horvitz et al., 2003) developed methods for inferring attention from multiple streams of information, and for leveraging these inferences in decision-making under uncertainty. These methods have been used in illustrative applications of the use of attentional models. Applications focus on the design of new interfaces that take into account visual attention, gestures and ambient sounds as clues about a user's attention. These clues can be detected through cameras, accelerometers and microphones or other perceptual sensors and, along with the user's calendar, current software interaction and data about the history of user's interests, they provide valuable information about the status of a user's attention. The same project built Bayesian models aiming at dealing with uncertainty and reasoning about current or future user's attention taking as input all of the above clues. Moreover, it introduced the economic model of attention and information. The model computes the expected cost of disruption user's current activities and infers whether and how to alert the user and display incoming messages.

A significant stream of related work deals with the design of attentive user interfaces (e.g. see Vertegaal, 2003; Vertegaal et al., 2006). Shell et al. (2003) identify five key properties of attentive user interfaces: sensing attention, reasoning about attention, communication of attention, gradual negotiations of turns, and augmentation of focus. Wood et al. (2006) make the distinction between visual and auditory attention and discuss five themes that concern the nature and measurement of visual attention.

In order to analyse the issues related to the design of attention aware systems, Roda and Thomas (2006) have identified three aspects of attention management: (1) Detection of current user's attentional state. The system needs to establish what are the user's goals and current tasks, where is the user's attention focussed, and what is happening in the environment, (2) Detection and evaluation of possible alternative attentional state. The system establishes whether alternative foci are available, how important they may be for the user, and the cost effectiveness of possible focus switches, (3) Strategies for presentation of alternative states to the user (or maintenance of current focus). The system defines the strategies best suited to present the user with alternative foci.

In comparison to attention aware systems, our approach does not include sensor-based mechanisms for detecting the user's environment. We argue that for enterprise attention management, non-sensory based mechanisms provide a wealth of attentional cues such as users' scheduled activities (e.g. using online calendars), users' working context (e.g. by querying workflow or enterprise systems) and user's communication and collaboration patterns (e.g. using groupware and other communication tools). However, our system is tailored to support enterprise attention management by taking into account the business context and working preferences.

4.2 Proactive Information Delivery: A Role for Ontologies

Information and Communication Technologies (ICTs) have been used in several purposeful manners in order to support and facilitate KM activities (Alavi and Leidner, 2001). The basic usages of ICTs refer to supporting creation, storage/retrieval, transfer, and application of knowledge in organizations. Typical examples of ICTs used for the aforementioned purposes comprise communication and collaboration tools, brainstorming tools, knowledge mapping and mining tools, workflow and content and document management systems, Intranets, and many more which were named KM tools following the concept's hype in the last decade (Ngai and Chan, 2005). Lately, a new technological concept, called ontologies, lends its capacity on encapsulating shared and common understandings as a means to support knowledge sharing and reuse. Ontologies are increasingly seen as a key technology for enabling semantics-driven knowledge processing (Maedche et al., 2003). Our technical proposition also draws on ontologies' capabilities to model possible transformations of information inside an artefact i.e. interaction among components, changing of content and metadata, etc.

Ontologies have been primarily and largely used for enabling the sharing of common understanding of the structure of information among people and software agents as well as enabling reuse of domain knowledge and making domain assumptions explicit to name just few of the reasons for their necessity (Noy and McGuinness, 2001). The problem that we are trying to tackle in our domain of interest lies in the effective delivery of information to its seekers, the resolution of which requires grasping and modelling the transformations of the information while being used. Given its existence in a shared context (e.g. PAs) the ontological treatment of information as resource (enclosing both content and action) deems appropriate and necessary. Ontologies are sufficient in capturing both the concepts and the relations about information resources as well as the changes affecting them. Modelling information in that way allows mapping and switching between different contexts i.e. context of resource creation, (individual) context of resource application, (business) context of living.

4.3 Modeling attention

The main challenge for modeling a KM system in e-Government nowadays is modeling (efficiently) the attention of public administrators. Indeed, (human) attention capacity is the only resource which cannot be increased by improvements in the technology, as illustrated in Figure 1.

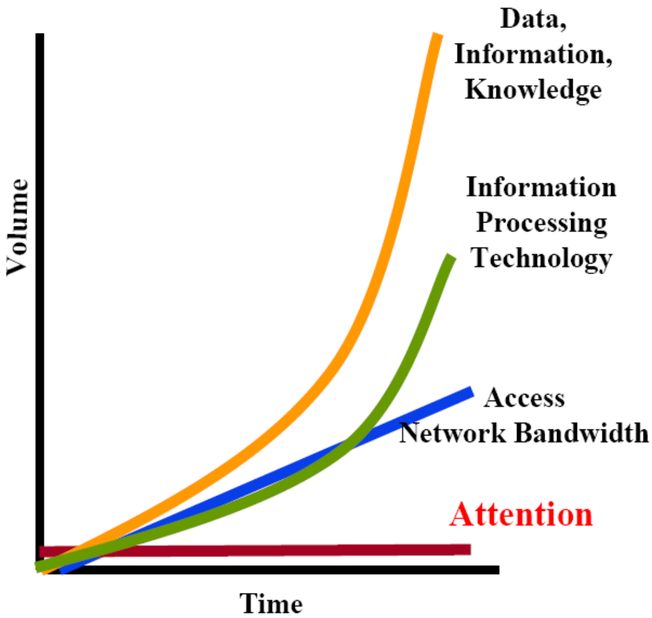

Figure 1. The importance of managing attention efficiently

On the other side, the amount of (relevant) information around public administrators is increasing dramatically, leading to the well known information overload problem. Therefore, managing access to relevant knowledge includes managing attention of knowledge workers.

Figure 2 presents our proposal for a framework for Attention Management. It is developed along 3 axes, corresponding to the aforementioned requirements:

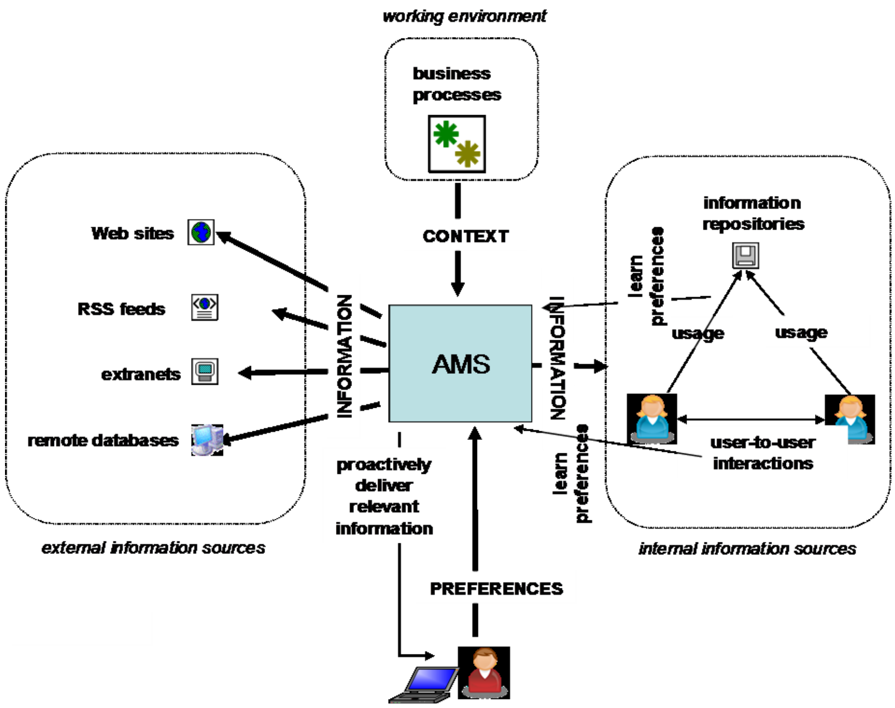

Figure 2. The Attention Management Framework

Information represents all relevant chunks of knowledge that can be found in the available information repositories and sources. In the business environment of an organization, sources of information can be both internal and external to the organization. Moreover, information can be represented either formally (e.g. using information structuring languages such as XML) or informally. Finally, information may be stored in structured repositories such as databases that can be queried using formal languages or in unstructured repositories such as discussion forums. We use a set of ontologies for representing information (and sources).

Context defines the relevance of information for a knowledge worker. Detection of context is related to the detection of the user's attentional state which involves collecting information about users' current focus of attention, their current goals, and some relevant aspects of users' current environment. The mechanisms for detection of user attention that have been most often employed are based on the observation of sensory cues of users' current activity and of the environment; however others, non-sensory based mechanisms also need to be employed to form a complete picture of the user's attentional state (Roda and Thomas, 2006).

Preferences enable filtering of relevant information according to its importance/relevance to the given user's context. In other words, the changeability of resources is proactively broadcasted to the users who can be interested in them, in order to keep them up to date with new information. Users may have different preferences about both the means they want to be notified and also about the relevance about certain types of information in certain contexts. User preferences can be defined with formal rules or more informally by means e.g. of adding keywords to user profiles. Moreover, even when employing mechanisms capable of formalizing the users' preferences, a certain level of uncertainty about users' preferences will always remain. For this reason, dealing with uncertainty is an important aspect of attention management systems. Equally important is the way preferences can be derived: by explicitly specifying them or by learning techniques.

5. A methodological approach for semantic realizations in PA's

The implementation of semantic-enabled knowledge-based e-government requires an appropriate methodological approach to cater for both the technical and organizational proceedings of the underlying endeavor.

The functions required of a knowledge management system cannot be known completely upfront. Thus, the design and deployment of any knowledge-based system should ideally follow an incremental approach, i.e. developers implement a part of the system and increment it rapidly, as new requirements emerge. A pilot implementation of the knowledge management system on a small scale can lead to insights that might prove to be invaluable before the fullblown system is implemented at an organisation-wide level. Thus, potential problematic aspects can be tackled with and reworked without major expense in order to comply with the actual needs of the end users and suit their preferences.

Taking the aforementioned into account, our methodological drive adopts the main principles of the Information Packaging methodology (IPM) primarily because of the iteration cycles of the latter throughout the design and development of a KM system lifecycle. In addition to that, the presented approach can be generally used by public administrations when taking-up semantic knowledge management initiatives. Consequently, it also takes into account a number of approaches and methodologies created in the frame of several EU-funded research efforts in the field of Knowledge Management. In specific, the proposed methodology takes into consideration the Know-Net method that has been designed as a supporting tool to help the design, development, and deployment of a holistic Knowledge Management Infrastructure, the CommonKADS leading methodology that supports structured knowledge engineering, and the DECOR Business Knowledge Method that constitutes a business process-oriented knowledge management method consisting of a structured archive around the notion of the company's business processes which are equipped with active, context-sensitive knowledge delivery, to promote a better exploitation of knowledge sources.

A diagrammatic overview of the methodological approach deployed in the public administration at hand is provided in the Figure 3.

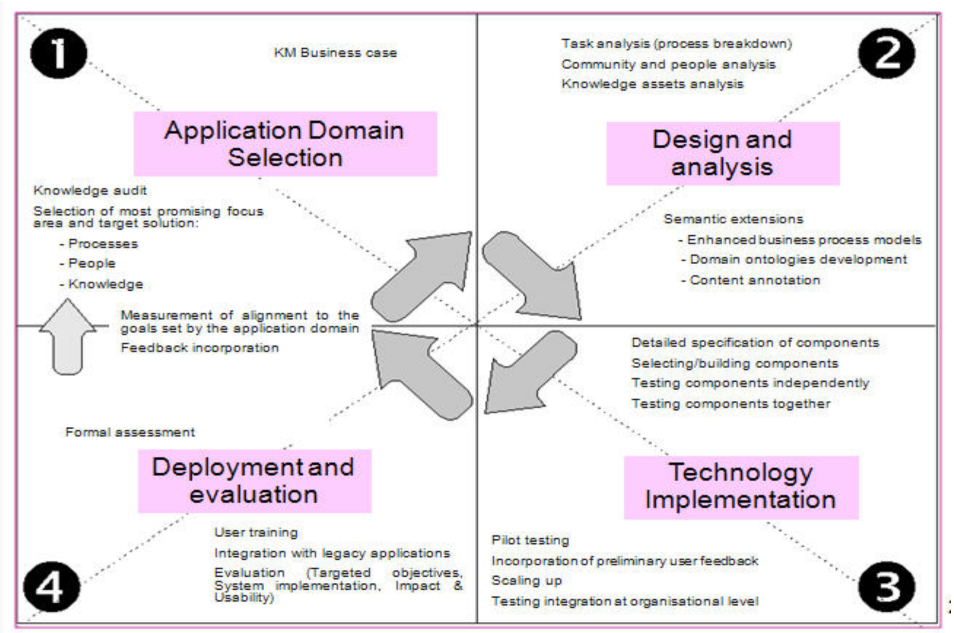

Figure 3: A methodology for semantically enabled technological interventions

The figure depicts an infinite loop between the methodology's steps as well as a respective feedback at the end of each one and before the start of the next one. The benefits of this approach are obvious; namely easier and more effective incorporation of iterative and incremental improvements to the knowledge management system under development. The smallest subset for running an iteration is defined on a per case basis. In majority, it comprises a business process in a PA but, in some cases, it can even be one complex task of the business process. In any case, the issue boils down to defining a meaningful set of functionalities to be implemented in the iteration system prototype, that can be used for testing and supplying feedback to the next iteration cycle.

The current methodological proporal comprises 4 steps/phases, namely:

- Step 1: Application Domain Selection, where the selection of the most promising area to focus is performed (e.g. a knowledge-intensive business process),
- Step 2: Design and Analysis, where a detailed analysis of the selected application domain is performed as well as the development of the system's semantic extensions,
- Step 3: Technology Implementation, where the implementation of the prototype takes place and then the prototype is tested (components independently at first and then together) in a small part of the

organisation. At this step a preliminary user feedback is collected that assists in order to scale up and test the prototype at the organisational level.

- Step 4: Deployment and Evaluation, where the prototype is being deployed in the organisation, potentially integrating with legacy applications. Users are trained in order to be able to use adequately the system and the system evaluation takes place. The results from the evaluation process serve as feedback to Step 1 in order to perform another iteration of the methodology either with the same or another application domain.

In the execution of the methodology the following roles participate:

- *External consultant*: A consultant that is not a member of the pilot public administration organisation,
- *Ontology engineer*: Anyone with profound knowledge and experience on the development of ontologies,
- *Domain expert*: An expert on a specific domain of interest,
- *Public administrator*: Any civil servant working in the public administration organisation,
- *Manager*: Anyone belonging to the higher management of the public administration organisation,
- *IT expert*: Anyone expert in Information Technology.

The added value of the current methodological undertaking in successful uptakes of KM initiatives is manifold. It is not constrained into driving simply the technological implementation of a semantically-enriched KM infrastructure but can reach to the point of restructuring the way the knowledge worker (a public administrator) performs his knowledge-intensive / decision making tasks.

For the purpose of this paper we focus on the way the methodology facilitates the modeling of attention of the knowledge worker, namely on steps 1 and 2 of the methodology. As aforementioned, modeling attention basically drills down to:

- Modeling information sources that should be accessed, in order to enable focusing on relevant ones,
- Modeling context in which information should be received, in order to define the business context in which information will be consumed,
- Modeling preferences of users, in order to express individual "context" in which information will be used.

All three requirements link to analyzing and modeling the knowledge landscape, namely the AS-IS situation of the organization but also, as a supplement to that, what can be deducted by looking at the present state and bearing in mind the future semantically-enhanced knowledge infrastructure of the targeted organization. A methodological approach spans the entire organizational context and knowledge environment in order to identify knowledge related problems and opportunities. More specifically it assists by providing the means for systematically:

- Identifying and capturing the knowledge assets that exist in the PA and the respective agents (key people) that posses but also use them, as well as changes that these knowledge assets are subject to. Those changes constitute obviously candidate reasons for triggering the attention of the public administrators.
- Defining simple as well as complex preferences with regard to users needs for specific information in a particular individual context via the detailed analysis of the knowledge assets, their changes and the involved agents, to the level of a single task in the business process of the PA.
- Extending/ enhancing the pre-existing ontologies (e.g. information ontology) as well as developing the per case domain ontology(-ies) taking into consideration the aforementioned modeling of knowledge and context in which this knowledge is used and consumed. These ontologies provide the backbone for the semantic-enriched knowledge infrastructure effectively empowering the public administrator and drawing his/her attention only to information pertinent to a particular business context or explicitly defined with a personal preference rule.

6. A prototype of an Enterprise Attention Management System (EAMS)

6.1 The Logical architecture

The vision of proactive information delivery based on attention management has been technically realized in an Enterprise Attention Management System (EAMS). The overall objective of the EAMS was to support knowledge workers always keep their attention focused on their current tasks by pre-selecting and feeding them with the most relevant information resources to complete their tasks in a way that will not disturb them more than they prefer.

Figure 4 depicts the logical architecture of the EAMS system that complies with the general Attention Management framework presented in Figure 2.

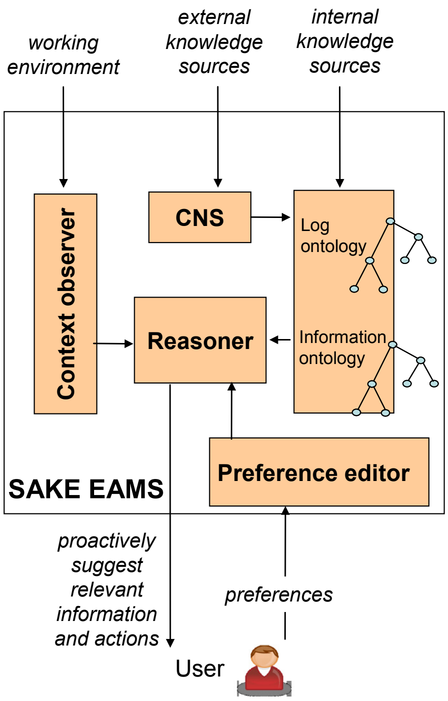

Figure 4. Logical Architecture of the Enterprise Attention Management System

The produced system incorporated public administrations' requirements for more effective, efficient and meaningful management of their knowledge landscape. To succeed in this, the Enterprise Attention Management System utilized the power of semantic technologies to cope with the information, the context and preference dimensions of PAs' requirements. The above axes were instantiated in three components of the EAMS, namely the Content Management System (CMS), the GroupWare System (GWS) and the Change Notification System (CNS).

The *content management system (CMS)* enables storage and provision of content by:

- supporting the annotation of content with metadata as well as relations between different content items;
- semi-automatic population of metadata using text mining methods; and
- realizing semantics-based search that retrieves content based on both full-text and metadata.

The *groupware system (GWS)* supports information sharing and creation by:

- supporting the annotation of the interactions between users;
- enabling identification of communities of practice from mining their interactions and their specific vocabularies by social tagging; and
- searching for experts based on their profiles as these are created explicitly and implicitly during their interaction with the system.

The *Change Notification System (CNS)* is a server-based change detection and notification system that monitors changes in the environment which is external to the system. It can be configured to monitor web pages, RSS feeds and contents of file servers. Users and the administrator can create new notification queries for finding and displaying interesting changes. When creating a query, users can define if they want to monitor a web page for any change or specific changes in links, words or a selected section specified by a regular expression. Moreover, users can select a topic of interest from a list. If new web page content is added that is related to the topic or an RSS feed update contains information related to the topic, then the user is notified.

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To conclude, the produced Enterprise Attention Management System comprises an engineering effort to transform the aforementioned attention management framework in technically and organizationally meaningful IT functions.

6.2 The Technical architecture

The EAMS prototype is based on J2EE and Java Portlets following a three-tiered architecture (Figure 5). The presentation tier contains Portlets, JavaServer Pages (JSPs) and an auxiliary Servlet. Portlets call business methods on the Enterprise Java Beans (EJBs), pre-process the results and pass them to the JSP pages. The JSPs contain Hypertext Markup Language (HTML) fragments as well as placeholders for dynamic content (such as the results passed from the Portlets). The auxiliary Servlet is used for initializing the connection to the KAON2 ontology management system part of the integration tier.

The business tier consists mostly of EJBs, which provide the business logic and communicate with the components of the integration tier that comprise a third-party CMS component (Daisy) and GWS component (Coefficient) as well the Preference Framework. The interface to these components is represented using EJBs which all use the Kaon2DAO in order to access the ontologies: the CMSBean and GWSBean enhance the CMS and GWS with semantic meta-data, the AMSBean manages the preference rules. KAON2 stores the semantic meta-data for these entities with ontologies and provides the facilities for querying them using SPARQL. The KAON2 reasoner is used for evaluating the user's preference rules. The integration tier contains also a MySQL relational database, which stores CMS- and GWS-related content, such as forums, discussions, documents etc.

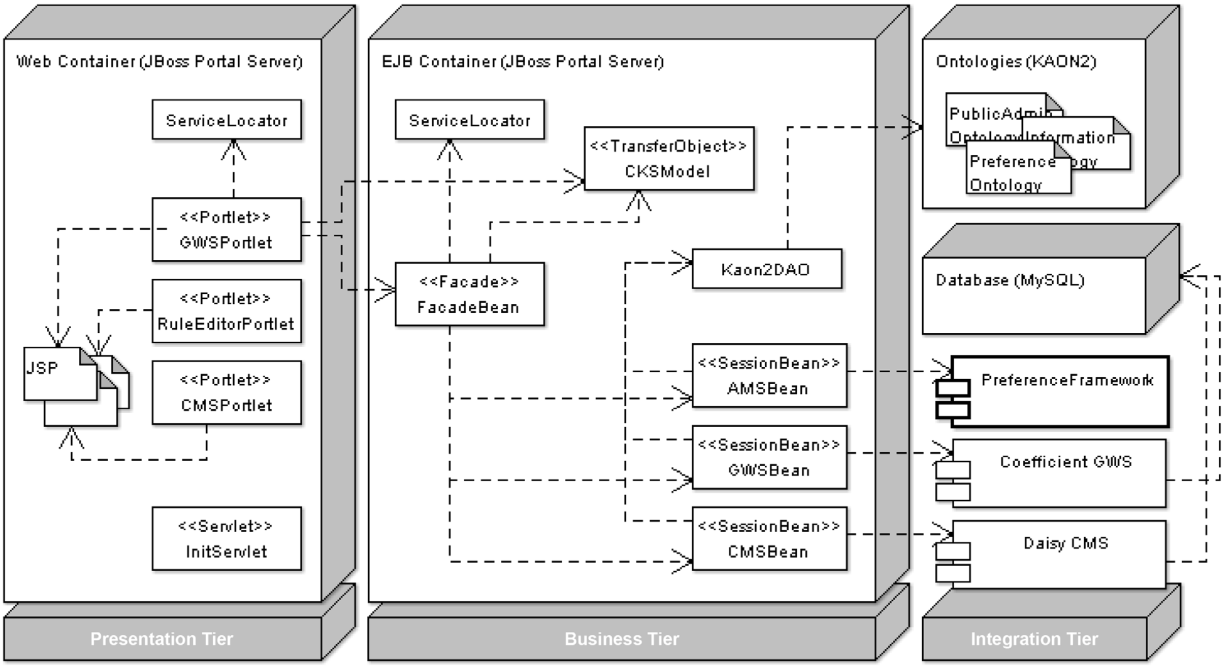

Figure 5. EAMS Technical Architecture

From a conceptual point of view, we have ensured that all components are based on a common ontological model for representing information resources and changes as well as context, roles and preferences. From the technical point of view we ensured standards-based interoperability by using state-of-the-art Semantic Web technologies, such as SWRL and SPARQL.

7. Conclusion

In this paper we presented a novel approach for managing attention in an enterprise context by realising the idea of having a reactive system that does not only alert users that something has changed, but also supports the user to react properly on that change. In a nutshell, the corresponding system is an ontology-based platform that captures changes in internal and external information sources, observes user context and evaluates user attentional preferences represented in the form of ECA rules.

Future work will be towards further refinement of ECA rules for preference description and automatic learning of preferences from usage data using machine learning techniques. Considering the existence of hierarchical relations that exist in the Log Ontology which models interactions (events) that occur in the system, we can further utilize Generalized Association Rules in order to mine and discover interesting patterns in the system's usage. The use of taxonomy by the Generalized Association Rules comprises a major improvement compared to standard association rules.

Finally, a strong focus towards refining and enhancing the methodology will be given, bearing in mind the imperative need of providing a clear methodology in one comprehensive document – for example as a handbook – in order to help potential users identify main problems and opportunities in the process of implementation.

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